MatchGraph!™
calculating velocity

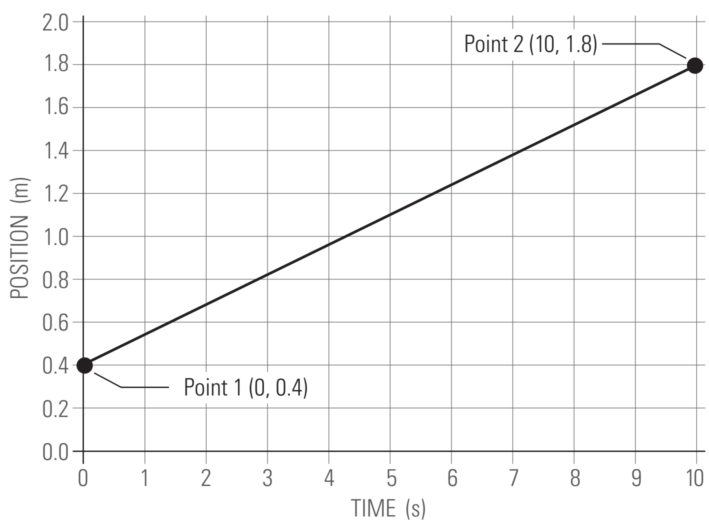
PASCO

Velocity is the speed of an object in a given direction. Velocity is used to describe the rate and direction that something is traveling. For example, The train was traveling north at 70 km/hour.Velocity is calculated with this formula:

$$\text{Velocity} = \frac{\Delta\ \text{Distance}}{\Delta\ \text{Time}}$$

To calculate the velocity of a line segment on a graph, coordinates at the beginning and the end of the line segment need to be identified (labeled below as "point 1" and "point 2"). The difference between these two points provides Δ distance and Δ time. In the graph below, the beginning and the end coordinates are also shown for points 1 and 2. For both of these points, the x-axis value (time) is shown first and the y-axis (position) is shown second.

GRAPH A



To calculate the velocity shown by this line segment, set up the velocity formula like this:

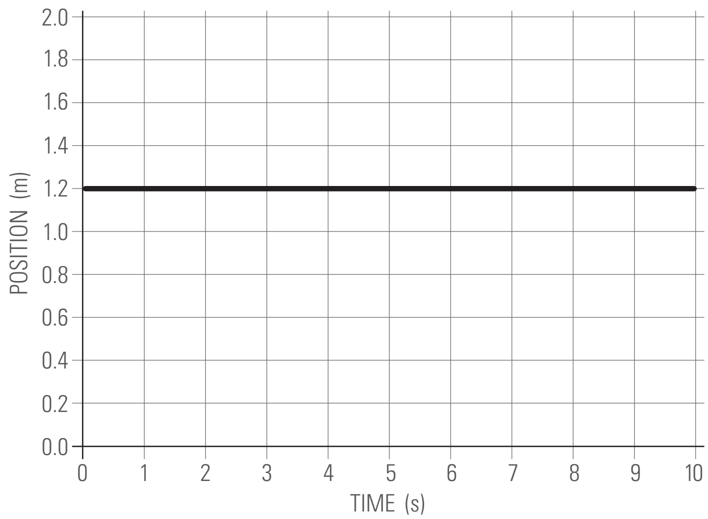
$$\text{Velocity} = \frac{\text{Distance 2} - \text{Distance 1}}{\text{Time 2} - \text{Time 1}} = \frac{1.8\ \text{m} - 0.4\ \text{m}}{10\ \text{s} - 0\ \text{s}}$$

Subtracting the initial distance and time from the second distance and time simplifies the equation to this:

$$\text{Velocity} = \frac{1.4\ \text{m}}{10\ \text{s}}$$

Solving the equation gives a velocity of 0.14 m/sec. Notice that the units of velocity are the y variable over the x variable. This is the slope of the line segment. Slope can also be expressed as "rise over run."

GRAPH B

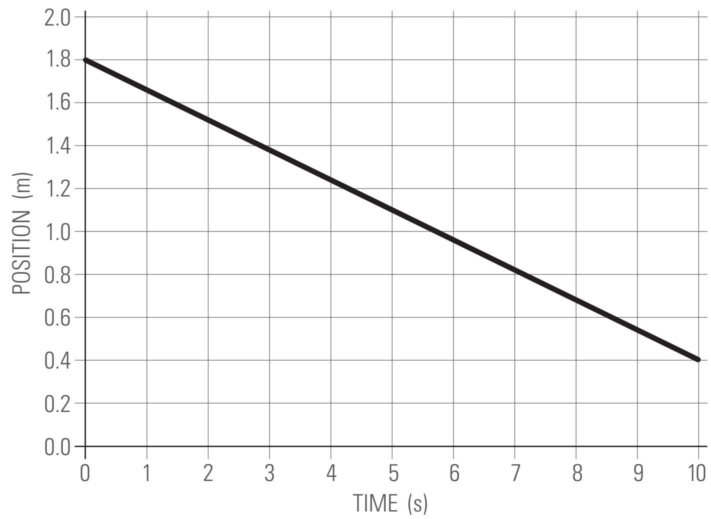


1. Calculate the velocity of the line segment in graph B.

2. What does the velocity indicate about the line in the above position vs. time graph?

3. How does the motion shown by graph B compare to graph A?

GRAPH C

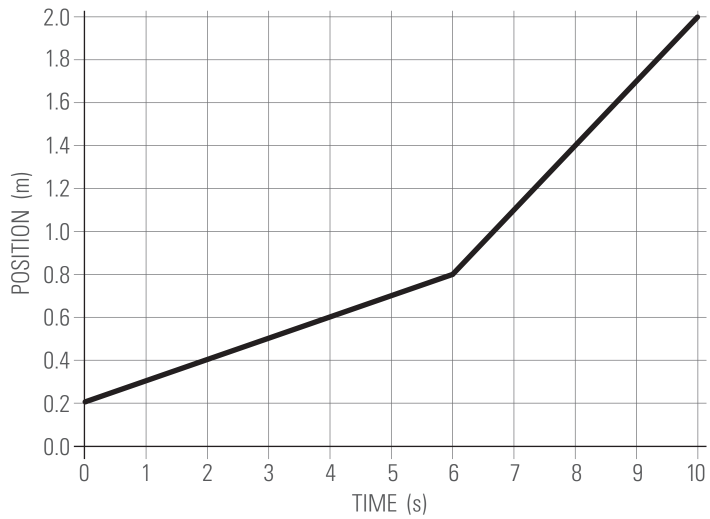


1. Calculate the velocity of the line segment in graph C.

2. What does the velocity indicate about the line in the above position vs. time graph?

3. What does a negative sign mean for a velocity?

GRAPH D



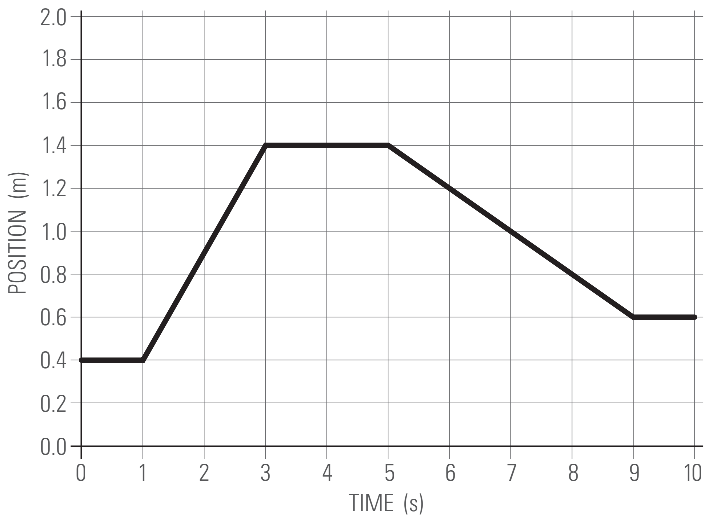
1. Predict how the velocities of the two line segments above will compare. Which part will be faster and which will be slower?

2. Calculate the velocities of the two line segments in graph D.

3. How did your calculations compare to your predictions? Explain how you know.

4. Do the velocities show that the distance is increasing or decreasing? How do you know?

GRAPH E

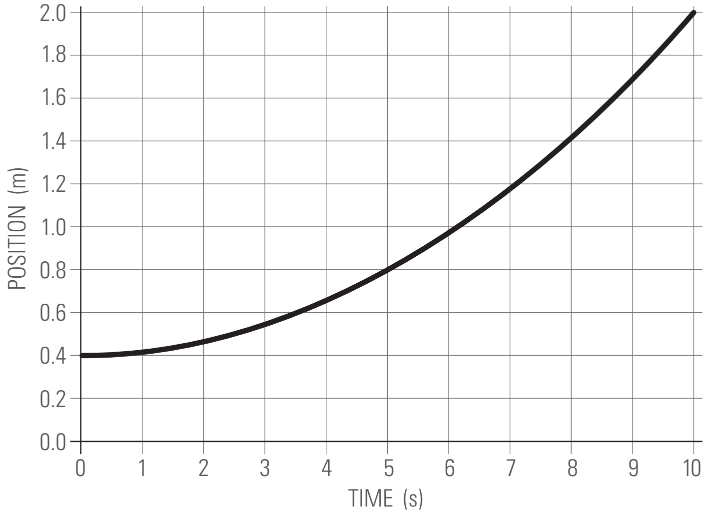


1. Calculate the velocities of the five line segments in graph E.

2. What can you tell about the initial conditions of this graph?

3. Describe how the velocity changes through the five line segments.

GRAPH F



1. What does a curving line indicate about velocity in contrast to a straight line?

2. Describe how the velocity changes through this graph. Calculate the slope between the points shown on the graph to do this.

3. What happens to velocity when a line is curving up? What happens when the line curves down?

Answer Key

GRAPH B

1. Calculate the velocity of the line segment.

$$\text{Velocity} = \frac{1.2\text{ m} - 1.2\text{ m}}{10\text{ sec} - 0\text{ sec}} = \frac{0\text{ m}}{10\text{ sec}} = 0\text{ m/sec}$$

2. What does the velocity indicate about the line in the position vs. time graph?

The line shows that no motion is occurring and the person is standing 1.2 m away.

3. How does the motion shown by graph B compare to graph A?

The line in graph A showed the person was moving away, with a constant velocity of 0.14 m/sec. The line in graph B is also constant, but no motion is occurring.

GRAPH C

1. Calculate the velocity of the line segment.

$$\text{Velocity} = \frac{0.4\text{ m} - 1.8\text{ m}}{10\text{ sec} - 0\text{ sec}} = \frac{-1.4\text{ m}}{10\text{ sec}} = -0.14\text{ m/sec}$$

2. What does the velocity indicate about the line in the above position vs. time graph?

The velocity of this line is traveling at -0.14 m/sec.

3. What does a negative sign mean for a velocity?

The negative sign indicates that an object is moving back towards the sensor. A positive sign would mean that an object is moving away from the sensor.

GRAPH D

1. Predict how the velocities of the two line segments above will compare. Which part will be faster and which will be slower?

Answers will vary. Students should predict that the second line segment shows a faster velocity than the first segment.

2. Calculate the velocities of the two line segments.

$$\text{Velocity (L1)} = \frac{0.8\text{ m} - 0.2\text{ m}}{6\text{ sec} - 0\text{ sec}} = \frac{0.6\text{ m}}{6\text{ sec}} = 0.1\text{ m/sec}$$

$$\text{Velocity (L2)} = \frac{2.0\text{ m} - 0.8\text{ m}}{10\text{ sec} - 6\text{ sec}} = \frac{1.2\text{ m}}{4\text{ sec}} = 0.3\text{ m/sec}$$

3. How did your calculations compare to your predictions? How you know.

Answers will vary. Students should either confirm or reject their predictions, and provide reasonable explanations as to why.

4. Do the velocities show that the distance is increasing or decreasing? How do you know?

The distance is increasing. This can be seen because the velocities for both line segments are positive.

Graph E

1. Calculate the velocities for the five line segments.

$$\text{Velocity (L1)} = \frac{0.4\text{ m} - 0.4\text{ m}}{1\text{ sec} - 0\text{ sec}} = \frac{0\text{ m}}{1\text{ sec}} = 0\text{ m/sec}$$

$$\text{Velocity (L2)} = \frac{1.4\text{ m} - 0.4\text{ m}}{3\text{ sec} - 1\text{ sec}} = \frac{1.0\text{ m}}{2\text{ sec}} = 0.5\text{ m/sec}$$

$$\text{Velocity (L3)} = \frac{1.4\text{ m} - 1.4\text{ m}}{5\text{ sec} - 3\text{ sec}} = \frac{0\text{ m}}{2\text{ sec}} = 0\text{ m/sec}$$

$$\text{Velocity (L4)} = \frac{0.6\text{ m} - 1.4\text{ m}}{9\text{ sec} - 5\text{ sec}} = \frac{-0.8\text{ m}}{4\text{ sec}} = -0.2\text{ m/sec}$$

$$\text{Velocity (L5)} = \frac{0.6\text{ m} - 0.6\text{ m}}{10\text{ sec} - 9\text{ sec}} = \frac{0\text{ m}}{1\text{ sec}} = 0\text{ m/sec}$$

2. What can you tell about the initial conditions of this graph?

The graph shows that the person is standing 0.4 meters away but is not moving.

3. Describe how the velocity changes through the five line segments.

The velocity starts at 0 m/sec for 1 second. Then the velocity increases to 0.5 m/sec from 1 to 3 seconds. The velocity again becomes 0 m/sec from 3 to 5 seconds. The velocity changes -0.2 m/sec from 5 to 9 seconds. The velocity then becomes 0 m/sec again for the last second.

GRAPH F

1. What does a curving line indicate about velocity in contrast to a straight line?

A curving line indicates that the velocity is changing through time. The velocity is not staying the same each second. A straight line would mean that the velocity was staying constant during the length of time shown by the line segment.

2. Describe how the velocity changes through this graph. Calculate the slope between the points shown on graph F to do this.

Depending on the math concepts that your students have mastered, students may have to estimate the distance of some of the values shown on the graph. Note that average velocities are calculated in this way for each second along the graph. Students will also calculate approximated velocities, as this activity does not assume that they know yet how to calculate a quadratic equation.

$$\text{Velocity (L1)} = \frac{0.42\text{ m} - 0.4\text{ m}}{1\text{ sec} - 0\text{ sec}} = \frac{0.02\text{ m}}{1\text{ sec}} = 0.02\text{ m/sec}$$

$$\text{Velocity (L2)} = \frac{0.46\text{ m} - 0.42\text{ m}}{2\text{ sec} - 1\text{ sec}} = \frac{0.04\text{ m}}{1\text{ sec}} = 0.04\text{ m/sec}$$

$$\text{Velocity (L3)} = \frac{0.54\text{ m} - 0.46\text{ m}}{3\text{ sec} - 2\text{ sec}} = \frac{0.08\text{ m}}{1\text{ sec}} = 0.08\text{ m/sec}$$

$$\text{Velocity (L4)} = \frac{0.66\text{ m} - 0.54\text{ m}}{4\text{ sec} - 3\text{ sec}} = \frac{0.12\text{ m}}{1\text{ sec}} = 0.12\text{ m/sec}$$

$$\text{Velocity (L5)} = \frac{0.8\text{ m} - 0.66\text{ m}}{5\text{ sec} - 4\text{ sec}} = \frac{0.14\text{ m}}{1\text{ sec}} = 0.14\text{ m/sec}$$

$$\text{Velocity (L6)} = \frac{0.98\text{ m} - 0.8\text{ m}}{6\text{ sec} - 5\text{ sec}} = \frac{0.18\text{ m}}{1\text{ sec}} = 0.18\text{ m/sec}$$

$$\text{Velocity (L7)} = \frac{1.19\text{ m} - 0.98\text{ m}}{7\text{ sec} - 6\text{ sec}} = \frac{0.21\text{ m}}{1\text{ sec}} = 0.21\text{ m/sec}$$

$$\text{Velocity (L8)} = \frac{1.44\text{ m} - 1.19\text{ m}}{8\text{ sec} - 7\text{ sec}} = \frac{0.25\text{ m}}{1\text{ sec}} = 0.25\text{ m/sec}$$

$$\text{Velocity (L9)} = \frac{1.7\text{ m} - 1.19\text{ m}}{9\text{ sec} - 8\text{ sec}} = \frac{0.51\text{ m}}{1\text{ sec}} = 0.51\text{ m/sec}$$

$$\text{Velocity (L10)} = \frac{2.0\text{ m} - 1.7\text{ m}}{10\text{ sec} - 9\text{ sec}} = \frac{0.3\text{ m}}{1\text{ sec}} = 0.3\text{ m/sec}$$

The velocity increases positively over time.

3. What happens to velocity when a line is curving up? What happens when the line curves down?

A line that is curving up means that the velocity is increasing and becoming more positive. A line that curves down means that a velocity is decreasing, becoming more negative.